Direction générale de l'Aviation civile

centre d'Études de la navigation aérienne

OPAS
an en-route and approach traffic fast time simulator for R&D and performance studies

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OPAS simulators family

- **FTS tools developped by CENA**
  - **OPAS : en-route simulations**
  - **OPAS-TMA : designed for TMA**
  - **Interface OPAS/OPAS-TMA : for E-TMA**

- **Ocaml language**
- **Lightweight, modular, tools :**
  - **OPAS : 3700 lines (not including comments)**
  - **OPAS-TMA : 5000 code lines**

➔ **easy to maintain, adapt to different concepts, test different conflict solving algorithms, ...**

OPAS simulators family

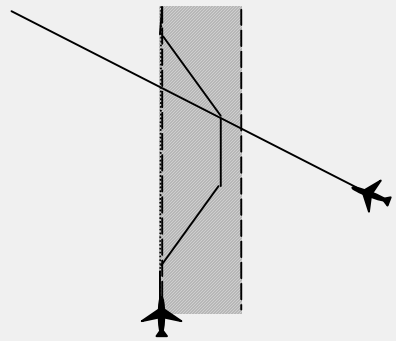
- **Used for Fast Time Simulations :**
  - **test new concepts and new algorithms**
  - **use different navigation logics, dynamic choice of trajectory**
  - **provide figures to evaluate performance indicators**
  - **if needed compute these performance indicators during simulation**

OPAS

- **En-route FTS, developped & used since 1998**
- **Input :**
  - **flight plans (FR, CEAC), performance model (BADA 3.5), sectors, beacons, airports, restricted areas, weighting factors (workload evaluation)**
- **Output recorded :**
  - **Sector entry/exit times, flows though sectors, conflicts (where, aircrafts involved, type, ...), ...**
  - **more generally everything based on geometry**
- **Studies :**
  - **RVSM**
  - **Distance (Radar tracks/direct routes/fixed routes)**
  - **MFF Project (Free-Route, ACP)**

OPAS - Flexibility example 1/5

- **Simulation of ASAS Crossing Procedures (ACP)**
  - **crossing delegation to the cockpit under certain circumstances**
- **Conditions of applicability :**
  - **some are easy to test : aircraft equipment, geometry, speed compatibility, ...**
  - **some require a special simulation : manoeuver remains in a given enveloppe and does not interfere with surrounding traffic**
- **Exemple - lateral crossing**

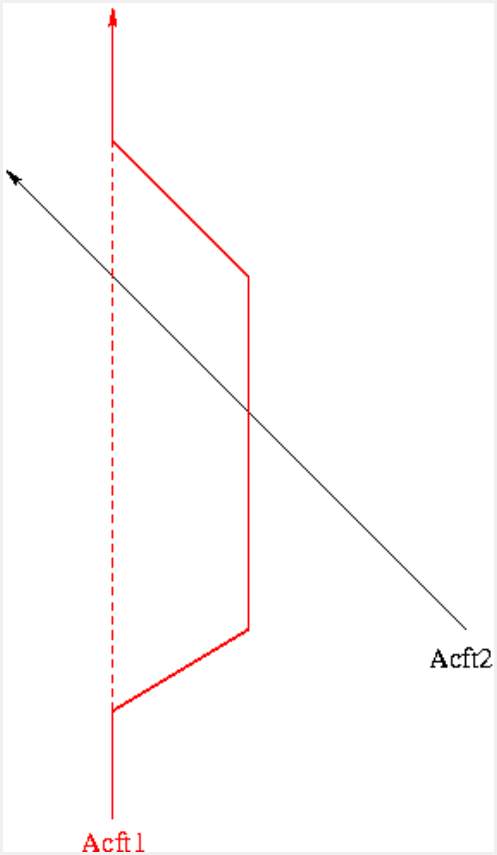


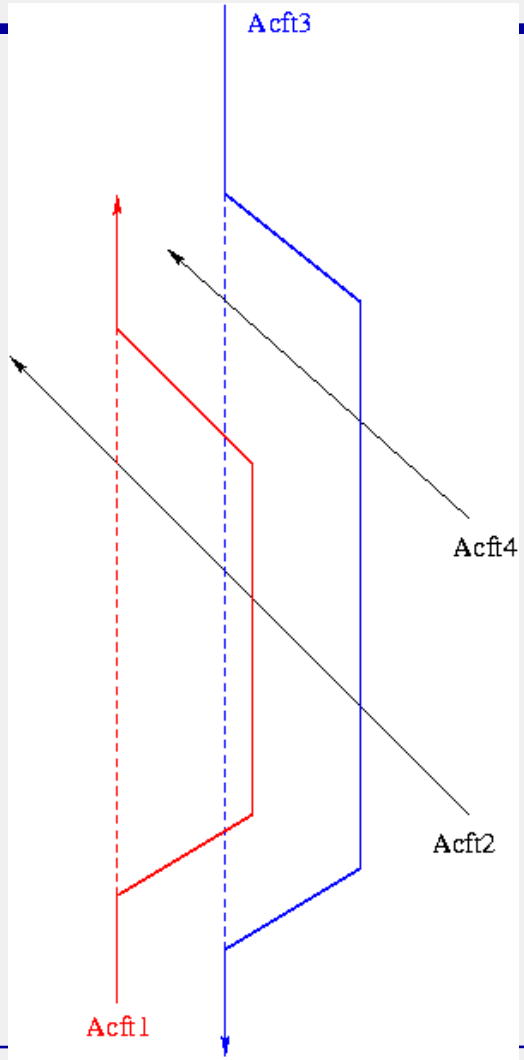
OPAS - Flexibility example 2/5

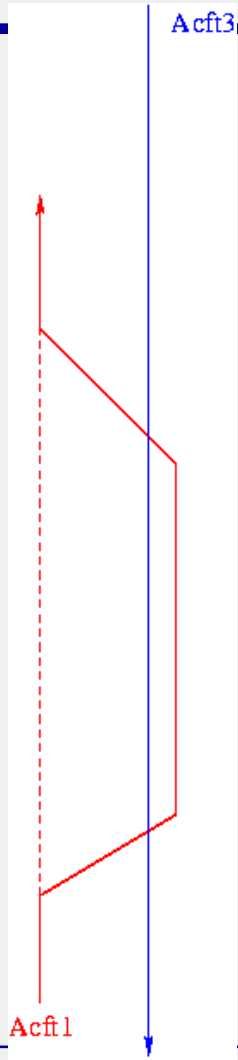
- **For each conflict**
  - **test if general conditions are met (equipment, speeds, ...)**
  - **test ACP to evaluate if other geometrical conditions are OK (taking into account only the 2 concerned aircraft)**
  - **if tests are OK : fly with ACP**

- **But...**
  - **Problem because an ACP can influence other ACPs**
    - multiple backtracks needed

OPAS - Flexibility example 3/5







OPAS - Flexibility example 4/5

- **Idea : define a « ghost » aircraft**
  - **aircraft executes the ACP clearance (A1)**
  - **corresponding ghost flies normally along its originally planned route (A2)**
  - **event recording for both aircraft and links between A2 and other ACPs detected**
  - **if ACP complies with conditions then keep trajectory of A1 else keep A2 (ignore this ACP and cancel influenced ACPs when needed)**
- **This method is much more efficient that doing multiple backtracks**
  - **initially : 24 hrs for a single simulation**
  - **after simulation core adaptation : 30 mins**

OPAS - Flexibility example 5/5

- **Efficient method allows multiple simulations**
  - **different traffic levels**
  - **5 equipment rates**
  - **different parameters for ACP conditions of use**

- **New elements easily recorded during simulation :**
  - **number of ACP**
  - **types**
  - **location**
  - **geometry of the encounter**
  - **handover to a neighbouring sector during the execution of an ACP**

OPAS-TMA

- **Based on OPAS simulator, designed for TMA**
- **Main goal : produce realistic aircraft trajectories in the vectoring area**
- **Development started mid-2001**
  - **validated on Paris-Orly airport**
  - **now being used for studies (Lyon airport)**
  - **Roissy CDG planned**
- **For environment & procedures changes studies**

OPAS-TMA

- **Input :**
  - **flight plans**
  - **performance model**
  - **beacons, runways, stacks, ..**
  - **procedures (adapted from SIDs and STARs with help from controllers)**

- **Output :**
  - **trajectories (x, y, z, t, heading, speeds, ...)**
  - **statistics on flight time/distance**
  - **number of flights that should be delayed (stacks, AMAN, ...)**
  - **...**

OPAS-TMA

- **Trajectory generation :**
  - **based on the definition of degrees of liberty (controllers)**
    - heading, speed, flight level
  - **needs a sequence (calculated, arrival/departure manager)**
  - **for aircraft N choose manoeuvers according to the available degrees of liberty so that**
    - flight time is minimized
    - no conflict with previous N-1 aircraft
    - wake turbulence taken into account when close to the runway
    - respect forbidden/compulsory volumes
- **Demonstration this afternoon...**

OPAS/OPAS-TMA interface

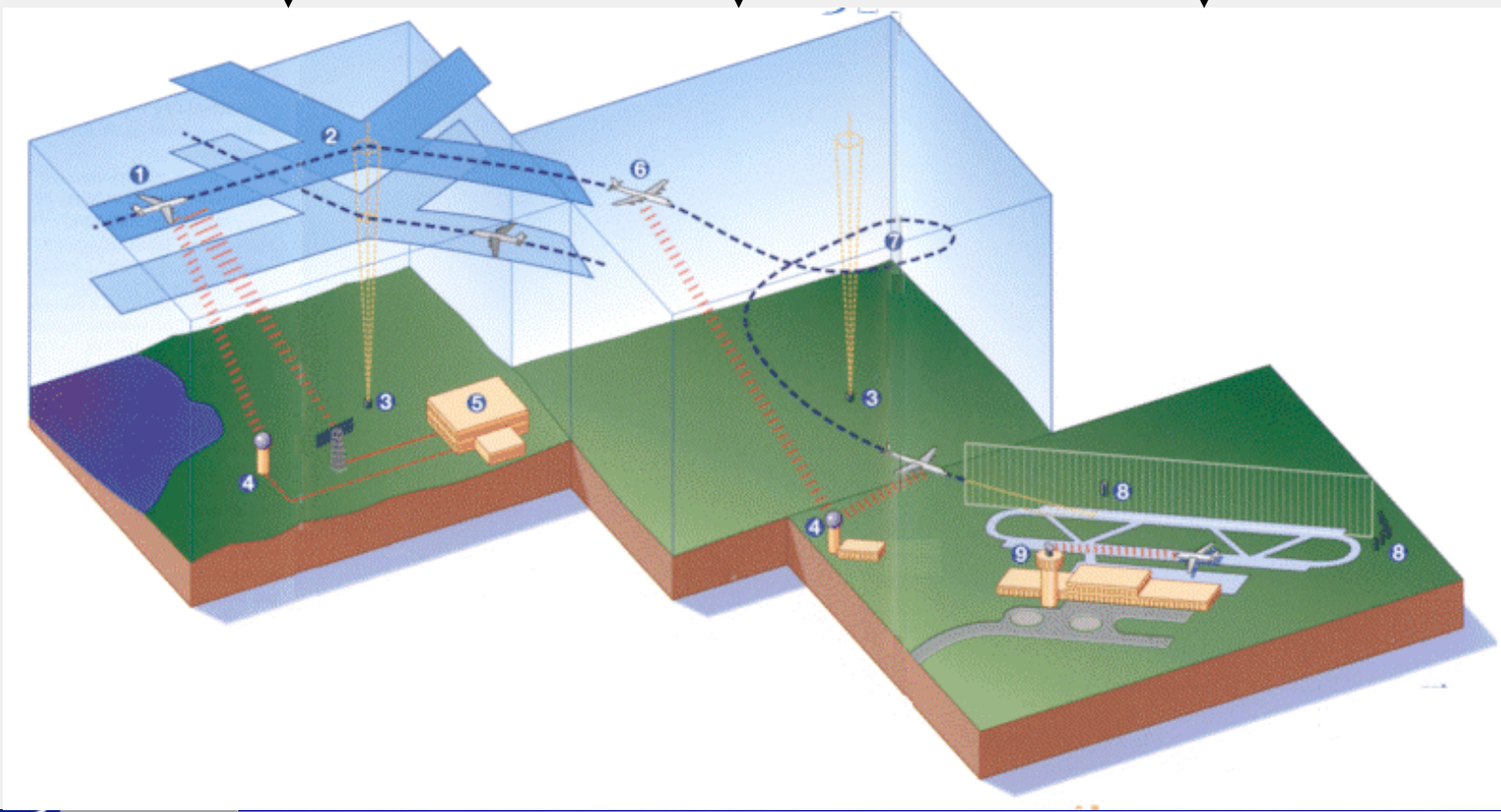
- **Allow FTS in E-TMA with good precision**
- **Main challenge : connect two simulators having different logics**
  - **In OPAS, aircraft are simulated simultaneously**
  - **In OPAS-TMA, aircraft are simulated one after another because this is best suited for TMA**
- **Has been developped**
- **Is being tested**
- **2004 : Gate2Gate = Paris area simulation (ACC+airports)**

OPAS/OPAS-TMA interface

OPAS

OPAS-TMA

Airport sim.



Conclusion

- **Code availability allows :**
  - **measurement of new indicators**
  - **efficient simulation of new concepts**
  - **modification of core navigation module**
  - **testing of new algorithms (conflict resolution)**
- **Drawbacks :**
  - **to get the best of the flexibility, knowledge of computer science is necessary**
- **Other limitations :**
  - **no graphical interface to define parameters for OPAS**